Skid Steer Vehicle with Ste rable Laterally-Extending Susp nsions

Related Applications:

[0001] This application is a continuation-in-part of, and claims 35 USC 120 priority to, U.S. patent application number 10/136,129 for a "Skid Steer Loader" to Brian E. FELSING, Anthony J. LAMELA, and Troy D. BATEMAN, filed on May 1, 2002 and published on November 6, 2003 as Publication Number US 2003/0205424 A1.

Field of the Invention

[0002] This invention relates to skid steer vehicles having sprung suspensions. More particularly, it relates to skid steer vehicles having steerable and laterally-extending suspensions.

Background of the Invention

[0003] Skid steer vehicles were devised some thirty years ago to provide a small, highly maneuverable work vehicle that could operate in close cooperation with workers at a worksite.

[0004] The classic skid steer vehicle has an implement, such as a bucket or pavement breaker disposed at the front of the vehicle that extends from one or two pivoting arms.

[0005] The vehicle itself rests on a chassis from which four or six wheels extend, generally all the same size, to support the vehicle and drive the vehicle over the ground.

[0006] In its original configuration, the wheels of the skid steer vehicle were ganged together in an unusual arrangement: the wheels on one side of the vehicle were linked to be driven together at the same speed by one drive motor,

and the wheels on the other side of the vehicle were linked to be driven together by another drive motor.

[0007] The movement of the wheels on each side of the vehicle were independent of each other: the operator can, by a variety of devices, rotate the wheels on one side of the vehicle at one speed and in one direction, and also rotate the wheels on the other side of the vehicle at another speed, and (if desired) in another direction.

[0008] In this manner, the skid steer vehicle can be driven forward or backward, but at another extreme, can be rotated in place without moving forward or backward, by the expedient of rotating the wheels on opposing sides of the vehicle in opposite directions at the same speed. Any intermediate motion between these extremes is also provided by the traditional system.

[0009] To turn a traditional skid steer vehicle one rotates the wheels on opposing sides of the vehicle in opposite directions (for turning in place) or at different speeds (for more gradually turning). This movement at different speeds or in different directions causes the wheels to skid across the ground. This skid steering occurs when a wheel moves with respect to the ground along a vector that is not perpendicular to the axis of the wheel's rotation.

[0010] Conventional skid steer vehicles travel at relatively low speeds, ranging up to 6-12 mph maximum. Skid steer vehicles are limited to these speeds because they historically lack sprung suspensions. Skid steer vehicles lack sprung suspensions primarily because of their intended design as small, inexpensive vehicles capable of travel around relatively small worksites that steer by skidding. Given the size, cost, speed and steering constraints, a sprung suspension was unnecessary and even a limitation in many uses.

[0011] This inability to operate above 6 mph is becoming a problem in the construction industry. Current skid steer vehicle engines have enough power to drive skid steer vehicles over the ground at higher speeds. The ride at these

higher speeds can be quite rough, however, since the conventional skid steer vehicles lack a suspension.

[0012] There is a need for a skid steer vehicle that travels faster to cover more ground during a typical work day. There is a need for a suspended skid steer vehicle to permit this faster movement. There is also a need for a steerable skid steer vehicle suspension that is small and compact and that provides both conventional and skid steering.

[0013] It is an object of this invention to provide such a vehicle and suspension.

Summary of the Invention

[0014] In accordance with a first aspect of the invention, a skid steer vehicle is provided having a chassis, at least one left side drive motor at least one right side drive motor, and four suspensions including right front, right rear, left front and left rear suspensions, wherein the two left suspensions are pivotally coupled to the chassis, wherein the two left suspensions extend leftwardly and laterally away from the chassis, and wherein the two left suspensions are both drivingly coupled to the at least one left side motor to be driven at the same rotational speed, wherein the two right suspensions are pivotally coupled to the chassis, wherein the two right suspensions extend rightwardly and laterally away from the chassis, and wherein the two right suspensions are both drivingly coupled to the at least one right side motor to be driven thereby at the same rotational speed.

Brief Description of the Drawings

[0015] Other objects of the present invention and many of the attendant advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, in which like reference numerals designate like parts throughout the figures thereof and wherein:

[0016] **FIGURE 1** is a left side view of a skid steer vehicle in accordance with the present invention.

[0017] **FIGURE 2** is a partial cross sectional top view of the skid steer vehicle of **FIGURE 1** taken generally along section line 2-2 and showing the preferred arrangement of four steerable suspensions, the chain tank and the left and right side drive motors with wheels and the upper portion of the struts removed for clarity.

[0018] **FIGURE 3** is a left side view of the left front suspension of the vehicle of **FIGURES 1 and 2** showing the control arm arrangement with the left front wheel removed for ease of viewing. This arrangement is the same for all four suspensions.

[0019] **FIGURE 4** is a front view of the left front suspension of the vehicle of the foregoing **FIGURES** taken at section line 4-4 in **FIGURE 2** with the left front wheel removed for ease of viewing

[0020] **FIGURE 5** is a schematic illustration of the motor drive hydraulic circuit of the skid steer vehicle of **FIGURES 1-3**.

[0021] **FIGURE 6** is a schematic illustration of the hydraulic steering circuit for steering the suspensions of the vehicle of the foregoing **FIGURES**.

Detailed Description of the Invention

[0022] **FIGURE 1** illustrates a skid steer vehicle **100** having a chassis **102** and an engine **104** mounted thereon. The engine is coupled to and drives four hydraulic pumps including a left side hydraulic pump **106**, a right side hydraulic pump **108**, a hydraulic charge pump **110** and a hydraulic steering pump **112**.

[0023] The chassis **102** is supported on four wheels including a left front wheel **114**, a left rear wheel **116**, a right front wheel **118** (**FIG. 2**) and a right rear wheel **120** (**FIG. 2**). Wheels **114**, **116**, **118**, and **120** are rotationally coupled to and driven by suspensions **122**, **124**, **126**, and **128**, respectively.

[0024] Left and right side loader lift arms, including left side loader lift arm **130**, are pivotally coupled to the chassis **102**. Left and right hydraulic lift cylinders, including left hydraulic lift cylinder **132** are coupled to and between the loader lift arms and the chassis to raise and lower the lift arms with respect to the chassis.

[0025] A bucket **134** is pivotally coupled to the end of the loader lift arms to pivot with respect thereto. Left and right bucket cylinders, including pictured left bucket cylinder **136**, are coupled to and between bucket **134** and the left and right loader lift arms, respectively, to pivot the bucket with respect to the cylinder.

[0026] The right side of vehicle **100** (not illustrated in **FIGURE 1**) is configured with a right side bucket cylinder, a right side loader lift arm and a right side hydraulic lift cylinder identically arranged as the pictured a left side bucket cylinder, left side loader lift arm and left side hydraulic lift cylinder.

[0027] Engine **104** is preferably an internal combustion engine such as a gasoline or diesel engine.

[0028] Left and right side hydraulic pumps **106** and **108** are preferably independently actuatable bi-directional variable displacement pumps--pumps that can be separately actuated to vary the flow rate of fluid through the pumps and also the flow direction.

[0029] The vehicle's load is transferred from the chassis through the suspensions and to wheels, which support the vehicle for travel over the ground. The wheels may be solid or pneumatic. They may be elastomeric or metal or a combination thereof. They are preferably all the same size and rotate at the same speed on each side of the vehicle. If the wheels on one side of the vehicle are of different overall diameter, they are driven by their respective motors on each side at different angular velocities such that the speed at their outer diameters (i.e. their over the ground speed) is the same.

[0030] **FIGURE 2** illustrates the vehicle in cross-section. It shows the structures of the suspension and drive system that drive the wheels in rotation and support the chassis on the wheel.

[0031] In the central portion of the vehicle's chassis **102** is a chain tank **200**. There are two motors, left drive motor **202** and right drive motor **204** that drive the let and right side wheels, respectively.

[0032] The left and right motors have shafts **206**, **208** that extend through chain tank sidewalls **210**, **212**. Sprockets **214**, **216**, **218**, **220** are coupled to and driven by the shafts. Sprockets **214**, **216** engage and drive forwardly extending chains **222**, **224**, and sprockets **218**, **220** engage and drive rearwardly extending chains **226**, **228**.

[0033] Chains **222**, **224** extend forward from sprockets **214**, **216** and engage sprockets **230**, **232** which are coupled, respectively, to forward drive shafts **234**, **236**. Shaft **234** extends laterally outward from the chain tank to the left and shaft **236** extends laterally outward from the chain tank to the right. Shaft **234** is drivingly coupled to left front wheel **114**. Shaft **236** is drivingly coupled to right front wheel **118**. The chains are comprised of chain links.

[0034] Chains **226**, **228** extend rearward from sprockets **214**, **216** and engage sprockets **238**, **240** which are coupled, respectively, to rear drive shafts **242**, **244**. Shaft **242** extends laterally outward from the chain tank to the left and shaft **244** extends laterally outward from the chain tank to the right. Shaft **242** is drivingly coupled to left rear wheel **116**. Shaft **244** is drivingly coupled to right rear wheel **120**. The chains are comprised of chain links.

[0035] Shafts **234**, **236**, **242**, and **244** are supported by bearings **246** at their inner ends where they pass through the sidewalls of the chain tank. Shafts **234**, **236**, **242** and **244** include flexible couplings **248** along their length to more easily accommodate the relative movement of the wheels they drive.

[0036] Alternative arrangements include providing four drive motors, wherein each suspension is provided with a drive motor to drive its respective drive shaft. In this manner the drive chains and multiple sprockets can be eliminated.

[0037] Suspensions **122**, **124**, **126** and **128** include control arms **247**, **249**, **250**, and **252**, respectively, that are coupled to and pivot up and down with respect to chassis **102**. These control arms are coupled to the chassis at forward pivot **254** and at rearward pivot **256**, which are located on chassis **102** sidewalls **251** and **253**, and which constrain the control arms to pivot up and down at their laterally extending outer ends **258** about a longitudinal and generally horizontal axis with respect to the chassis.

[0038] **FIGURES 3** and **4** illustrate the left front suspension, which is the same as all the other suspensions of the vehicle in its operation and construction. The right side suspensions are mirror images of the left side suspensions and the rear suspensions are mirror images of the front suspension.

[0039] While **FIGURES 3** and **4** illustrate the control arm arrangement of the left front suspension, they apply equally to the other suspensions of the vehicle, which are therefore not separately described herein.

[0040] The outer end **258** of left front control arm **247** is coupled to a strut **260** that extends upward from the control arm and is coupled to chassis **102**. The strut comprises an outer cylindrical portion **262** and an inner rod portion **264** that slides within the cylindrical portion **262**. A spring **266** is coiled around strut **260** to keep strut **260** extended. Spring **260** engages the cylindrical portion of the strut at its lower end and the vehicle chassis at its upper end, thereby supporting the weight of the vehicle.

[0041] The cylindrical portion and the rod portion of strut **260** may be configured not merely to slide, one within the other, but to function as a hydraulic spring or a hydraulic damper, or as a combined hydraulic spring and damper.

[0042] Strut **260** supports drive shaft **234** for rotation, holding the end of driveshaft **234** generally horizontal and parallel to the ground. The outer end of drive shaft **234** has a flange **268** with studs **270** extending therefrom to which wheel **114** is mounted.

[0043] When the vehicle chassis moves downward closer to the ground and the suspensions compress, the ground forces wheel **114** upward causing control arm **247** to pivot with respect to chassis **102** about the longitudinal and horizontal axis defined by forward pivot **254** and rearward pivot **256**. As control arm **247** pivots upward, strut **260** supports the drive shaft, permitting the outer end of the drive shaft and the wheel to move upward as the inner rod portion collapses into the cylindrical portion, and permitting drive shaft **234** to move up and down in slot **259** in sidewall **251** when the left front suspension moves up and down. The chassis **102** sidewalls at the other three suspensions have similarly located slots to accommodate upward and downward movement of their associated drive shafts.

[0044] Strut **260** is coupled to the outer end **258** of the control arm by a ball joint **265** that provides two degrees of freedom, permitting the lower portion of strut **260** to be steered about a generally vertical axis, and permitting the strut to hold driveshaft **234** generally horizontal whenever control arm **247** pivots upward or downward.

[0045] Strut **260** is steered by steering actuator **272**, which is coupled to strut **260** and chassis **102**. Steering actuator **272** pivots strut **260** about a generally horizontal axis causing the wheel to steer to the left, to the right, or straight ahead.

[0046] Steering actuator **272** is preferably a hydraulic cylinder that extends and retracts as hydraulic fluid is conducted into its extend and retract ports, respectively.

[0047] **FIGURE 5** is a schematic diagram of the hydraulic circuit that couples the left pump **106** and the right pump **108** to left and right side hydraulic drive motors **202**, **204**, respectively.

[0048] Left side hydraulic drive pump **106** is coupled in series with left side hydraulic motor **202** to drive hydraulic motor **202** and, through the left side sprocket, chain and drive shaft arrangement, to drive both of the left wheels simultaneously and in the same direction. Similarly, right side hydraulic drive pump **108** is coupled in series with right side hydraulic motor **204** to drive hydraulic motor **204** and, through the right side sprocket, chain and drive shaft arrangement, to drive both of the right side wheels simultaneously and in the same direction.

[0049] Pumps **106** and **108** are bidirectional--they can drive hydraulic fluid under pressure in both directions through the pump. As a result, they can drive their respective motors in both directions. Both the left and the right side drive pumps are variable displacement pumps that can be separately controlled by the operator. This independent and separate control permits the operator to drive the wheels on opposing sides of the vehicle in different directions, or in the same direction. It also permits the operator to drive the wheels on opposing sides of the vehicle at different speeds as well. The operator provides these different speed and different direction by electronically or manually changing the displacement of the pumps using manual or electronic actuators that are known in the art.

[0050] Pump **106** and motor **202** form a first series drive circuit. Pump **108** and motor **204** form a second series drive circuit that is independent of the first series drive circuit.

[0051] Each of these drive circuits has a hydraulic fluid makeup and pressure relief circuit **274**. Whenever the pressure in either of the series drive circuits drops below a minimum design pressure, circuits **274** supply make-up hydraulic fluid from hydraulic charge pump **110**. Whenever the hydraulic fluid pressure in

the series drive circuits rises above a maximum design pressure, circuits **274** dump hydraulic fluid from the series drive circuits to tank **276**.

[0052] **FIGURE 6** is a schematic diagram of the hydraulic circuitry that coupled to and controls the four steering actuators associated with each of the four suspensions. Actuator **272** steers the left front suspension. Actuator **278** steers the left rear suspension. Actuator **280** steers the right rear suspension and actuator **282** steers the right front suspension. These four actuators are coupled together in series with steering valve **284**, which, in turn, is in fluid communication with tank **276** and steering pump **112**.

[0053] Steering valve **284** directs hydraulic fluid into the four steering actuators to steer them left and right with respect to chassis **102**. The steering actuators are coupled together such that both the front wheels turn to the left and both the rear wheels turn to the right simultaneously when steering valve **284** is moved to its left ("L") position. Similarly, both the front wheels are turned to the right and both the rear wheels are turned to the left simultaneously when steering valve **284** is moved to its right ("R") position. Valve **284** is actuated electrically, as shown here, by solenoids **286** and **288**. Solenoid **286** moves valve **284** to the right and solenoid **288** moves valve **284** to the left. Alternatively, valve **284** may be actuated mechanically, pneumatically or hydraulically.

[0054] In place of the single valve **284** illustrated herein, alternative arrangements may include a plurality of valves coupled to the actuators in place of valve **284**. Each of these valves may separately control the flow of fluid to and from each actuator. In addition, position sensors may be provided to indicate the actual position of the actuators, thereby permitting a control circuit (either electrical, mechanical, hydraulic or pneumatic, or a combination thereof) to coordinate the steering of each actuator with the other actuators. Other familiar hydraulic circuit elements such as pressure relief valves and makeup circuits may also be combined with the circuit elements of **FIGURE 6**.

[0055] One preferred means for actuating the solenoids includes an electronic controller **290**. Electronic controller **290** includes a microprocessor, RAM, ROM and driver circuits coupled together with control, address and data buses to drive the solenoids of valve **284** and to control the displacement of hydraulic drive pumps **106** and **108**. The controller is configured by programmed instructions in ROM, causing controller **290** to respond to operator manipulation of joystick **292** by changing the wheels speed and direction of rotation, and by steering the wheels with respect to the chassis.

[0056] When the operator manipulates joystick **292**, controller **290** is configured by its programmed instructions to responsively steer the vehicle by controlling the steering actuators. It is also programmed to responsively skid steer and drive the vehicle by controlling pumps **104** and **106**, to which it is operatively coupled.

[0057] In response to operator joystick **292** commands, controller **290** is configured to steer the vehicle as a conventional vehicle by energizing the solenoids of valve **284**, thereby turning the wheels to steer left and right, while simultaneously driving all the wheels in forward or all in reverse. Controller **290** is also configured to skid steer the vehicle, by driving the wheels on one side in a direction or at a speed different than the wheels on the other side of the vehicle. Controller **290** does this by changing the displacement of the hydraulic drive pumps **106** and **108** to which it is coupled. Controller **290** is also configured to steer all four wheels into straight ahead positions when the controller is in the skid steering mode by controlling the position of valve **284** to which it is coupled.

[0058] It will be understood that changes in the details, materials, steps, and arrangements of parts which have been described and illustrated to explain the nature of the invention will occur to and may be made by those skilled in the art upon a reading of this disclosure within the principles and scope of the invention. The foregoing description illustrates the preferred embodiment of the invention; however, concepts, as based upon the description, may be employed in other

embodiments without departing from the scope of the invention. Accordingly, the following claims are intended to protect the invention broadly as well as in the specific form shown.